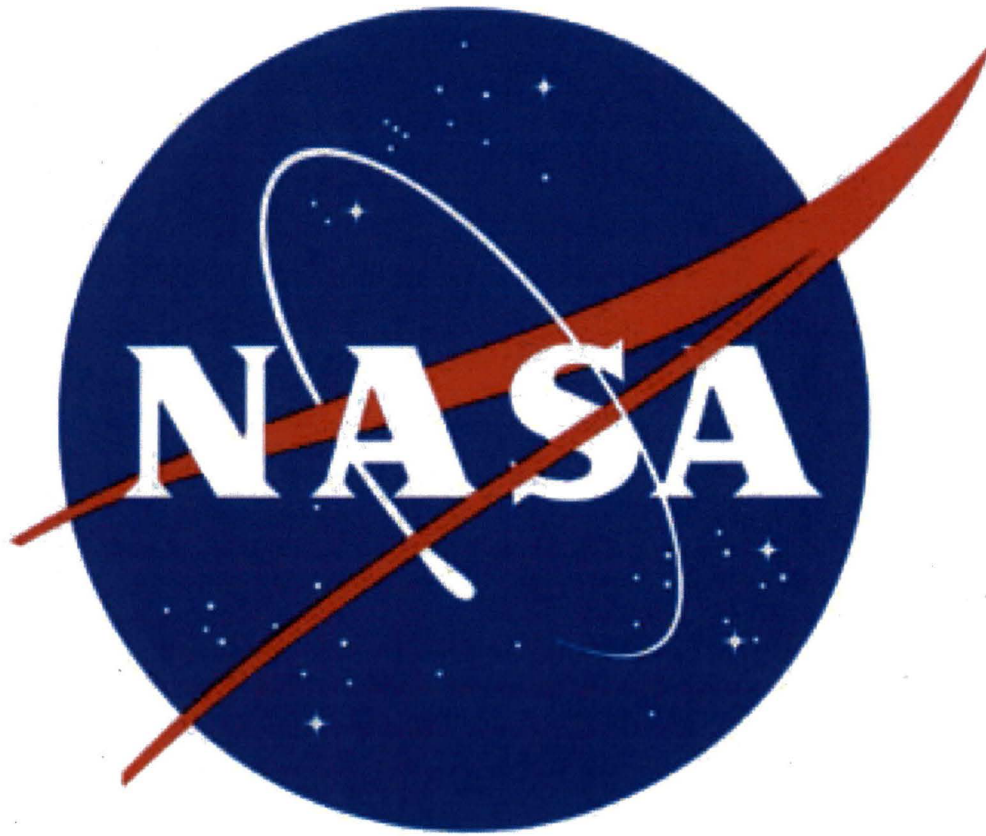


## Spring 2013 Graduate Engineering Internship Summary



### Student

Joshua Ehrlich

[REDACTED]

[EhrlichJ@my.erau.edu](mailto:EhrlichJ@my.erau.edu)

ME 696, Fall 2013

Master of Science in Mechanical Engineering Student

NASA, Materials Science Division: Failure Analysis & Materials Evaluation (NE-L1)

Graduate Engineering Intern

### Supervisor

Steven McDanel

321-861-8969

[steve.mcdanels@nasa.gov](mailto:steve.mcdanels@nasa.gov)

NASA, Failure Analysis & Materials Evaluation, NE-L1 Branch Chief

In the spring of 2013, I participated in the National Aeronautics and Space Administration (NASA) Pathways Intern Employment Program at the Kennedy Space Center (KSC) in Florida. This was my final internship opportunity with NASA, a third consecutive extension from a summer 2012 internship. Since the start of my tenure here at KSC, I have gained an invaluable depth of engineering knowledge and extensive hands-on experience. These opportunities have granted me the ability to enhance my systems engineering approach in the field of payload design and testing as well as develop a strong foundation in the area of composite fabrication and testing for repair design on space vehicle structures.

As a systems engineer, I supported the systems engineering and integration team with final acceptance testing of the Vegetable Production System, commonly referred to as Veggie. Verification and validation (V&V) of Veggie was carried out prior to qualification testing of the payload, which incorporated the process of confirming the system's design requirements dependent on one or more validation methods: inspection, analysis, demonstration, and testing. This was a critical aspect for the Acceptance Data Package (ADP). The ADP is a combination of several documents and reports managed by both NASA and the supplier, ORBITEC. This package includes all correspondence between the customer and supplier, quality control documents, acceptance inspection records and any other required documentation necessary for the completion of the build contract between the two parties. The responsibility of the systems engineers was to retrieve and compile the testing results NASA collected during qualification testing in order to verify that the measurements recorded during those tests were compliant to the intended levels according to the system requirements. These results were based on processes within functional, vibrational, acoustic, electromagnetic interference (EMI), and payload rack and checkout unit (PRCU) testing. The Veggie requirements used for validation both the design and science requirement documents, as well as the International Space Station (ISS) Program's EXpedite the PROcessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document, which defines what requirements a payload must meet when interfaced to an EXPRESS rack within the ISS (Figure 1).

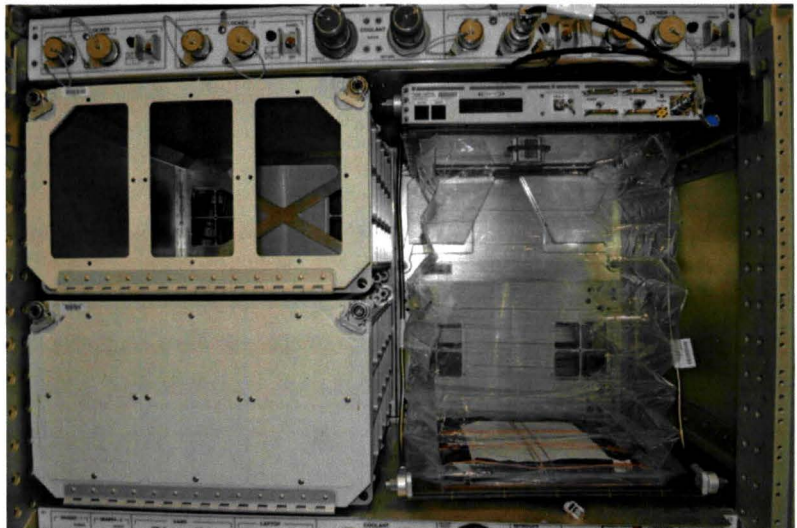


Figure 1 – Veggie undergoing PRCU testing to verify system will meet dimensional constraint and Human Factors Integration Team (HFIT) requirements within the EXPRESS rack.

In order to conduct turnover of Veggie, where NASA accepts full responsibility of flight hardware upon completion by an external contractor, engineers must verify that all tests outlined within the V&V were conducted properly in conjunction with the testing documentation. Additionally, tests run on the payload per the V&V per requirement produced acceptable data and results in adherence with the limits



or values of each requirement. These testing procedures were completed at several NASA centers spread out all across the country, including Marshall Space Flight Center, Johnson Space Center, and Kennedy Space Center. In addition, several qualification tests were completed at the contractor's facility in Madison, Wisconsin. The next event for Veggie is Payload Verification Testing (PVT), which will involve placing plants within the payload's growth chamber to expose the payload to experimental working environments such as variable levels of humidity, temperature, carbon dioxide, and ethylene.

Furthermore, I served as a systems engineer for the Plant Habitat (PH) payload, a self-sustaining, environmentally-controlled growth chamber to be stationed onboard the ISS to support commercial and fundamental plant research; PH is anticipated to have the largest microgravity growth chamber ever spent into space. In February, the team completed a Preliminary Design Review (PDR), which is considered a 30% completion milestone criterion of the entire project. The review incorporated preliminary designs of the multiple subsystems incorporated within the payload, which included a composite-structured growth chamber, closed-loop Environmental Control System (ECS), Water Recovery and Delivery System (WRADS), Thermal Control System (TCS), Power Distribution Assembly (PDA), 900-Light Emitting Diode (LED) Growth Light Assembly (GLA), a tray-like science carrier structure, and multiple avionics and software units (Figure 2).

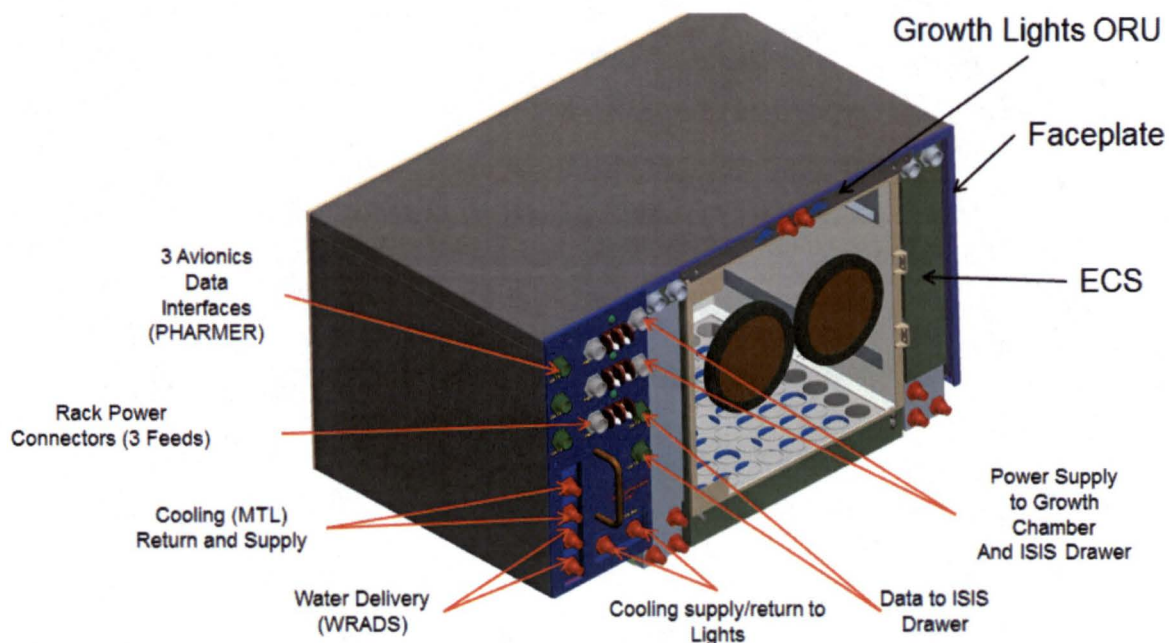


Figure 2 – PH hardware at the PDR level. The growth chamber will have the ability to extend 10 inches from the payload main structure in order for the ISS crew to manipulate plants through the glove access ports on the front faceplate of the chamber. ISS crew members will be able to view their handling techniques, including harvesting of the plants, through the clear, polycarbonate pane located at the top of the growth chamber. PH will support plant-specific experiments for up to 90 days.

Following completion of the PDR, the team was tasked to perform trade studies of the impacts of several design and science requirement alterations requested by NASA program management. The purpose of these trade studies and Review Item Dispositions (RIDs) were to determine how the new requirements would affect the costs to the project, which includes impact to schedule. The affects include the amount of time an engineer would require to conduct an analysis on the proposed design change, as well as monetary impact to the project. Prior to the initiation of prototyping and subsystem testing and integration, the engineering team must submit their impact trade studies prior to delta PDR, which is intended to confirm which design changes will be implemented in as new requirements in order for the project to commence into payload design completion en route to subsystem prototyping and testing.

Finally, I submitted a technical paper, "Process Optimization of Bismaleimide (BMI) Resin Infused Carbon Fiber Composite," which I will be presenting to the Society for Advancement of Materials and Processes Engineering (SAMPE) conference in Long Beach, California, in May 2013. Bismaleimide-2 (BMI-2) resin was used to infuse intermediate modulus 7 (IM7)-based carbon fiber into the cured composite fabric for which the project intended to produce. Curing of the BMI-2/IM7 system utilized an optimal infusion process which focused on the integration of the manufacturer-recommended ramp rates, hold times, and cure temperatures. Completion of the cure cycle for the BMI-2/IM7 composite yielded a product with multiple surface voids (Figure 3) detected via visual and metallographic observation. Based on these findings, it was determined the total void percentage identified within each composite panel analyzed contained less than 10% the allowable void content of the total composite area (based on use for aerospace applications). Shown in Figure 4 is a graph illustrating the void composition frequency based on the feret diameter size for each void measured during scanning electron microscope (SEM) porosity analysis. The purpose of this research was to develop an optimal repair patch system to be utilized on aerospace applications.

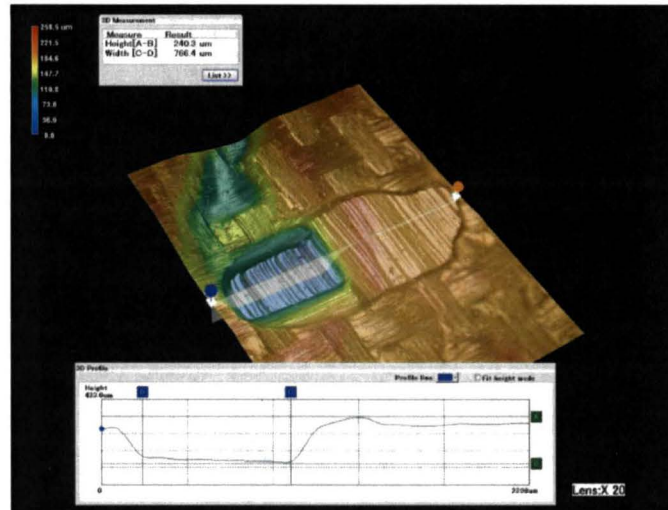


Figure 3 – Depth profile and 3-D projection @ 20X magnification of a single void found within a woven composite panel. The depth of the void was measured to be 240.3 $\mu\text{m}$  (.2403 mm), width 766.4 $\mu\text{m}$  (.7664 mm), and a total surface area of 1464.2 $\text{mm}^2$ .

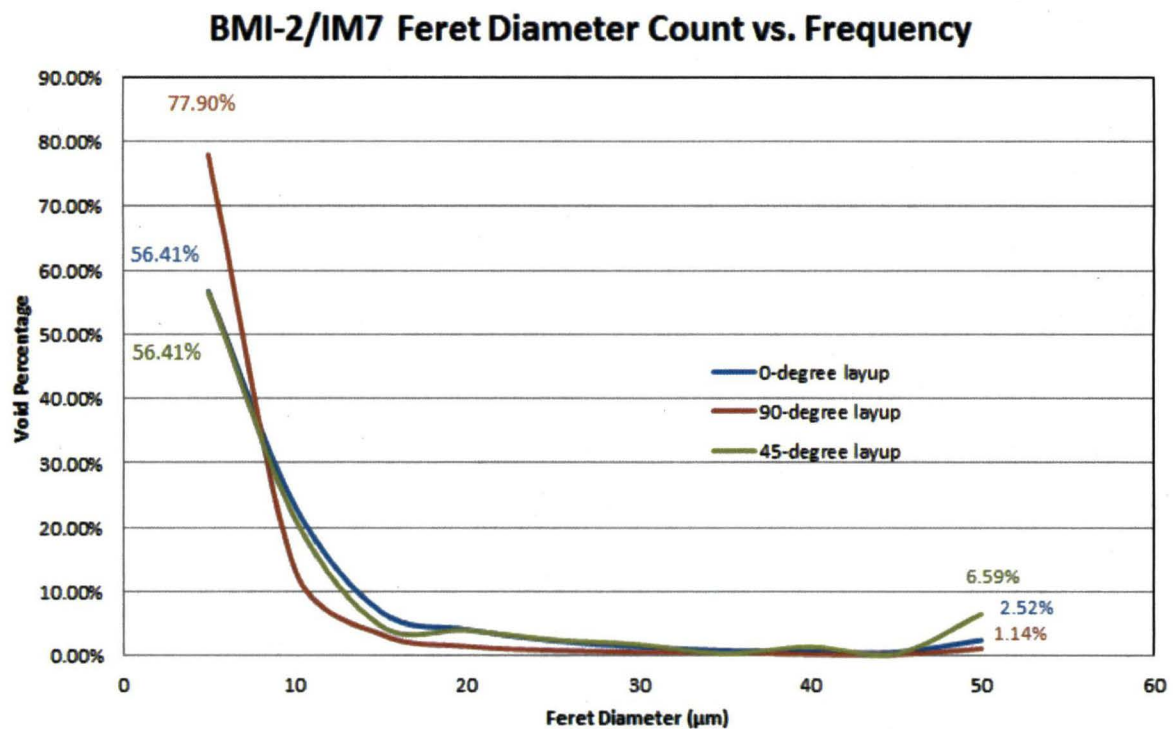


Figure 4 - Graph illustrating the varying feret diameter ( $\mu\text{m}$ ) voids found per BMI-2/IM7 layup and assigning a total % to that frequency discovered.

My tenure as a NASA intern was one of the greatest achievements I have accomplished in my life. The opportunity to work side-by-side with some of the greatest minds in the world was a monumental experience, one unlike any other internship I have had. The greatest part during my time at



Kennedy Space Center was my infinite ability to reach out and apply myself to any type of project or objective the team was addressing. Through the internships I have participated in, this was the one place I give recognition to where I had the opportunity to gain a full hands-on experience while playing a significant team role. Working on a multi-million dollar project is something not many companies trust their interns with. The team I worked with welcomed my thoughts, opinions, and ideas. This opportunity led to further development of my communication skills in delivering technical presentations to a large audience as well as enhancing my engineering technical knowledge in proposing project plans and design solutions.

My time spent at NASA has highlighted both my undergraduate foundation from the University of Florida and graduate-level skills obtained at Embry-Riddle Aeronautical University. Incorporating the systems engineering aspects from my coursework in SYS 500 and SYS 405 helped me tremendously in the field. I hope to encourage future engineers to follow their dreams and never give up on their passion for success. I have never strayed away from my goals, and I have and will continue to meet those challenges as they are presented to me in the future. If the past provides any indication to the future, then the path that lies in front of should be one that incorporates my knowledge and skills based upon my educational and professional experiences.